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Analysis of Energetic Material Detection Technologies for Use at Army Energetic Material Production Facilities

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Foreword

This study was conducted for the Directorate of Research and Development, Headquarters, U.S. Army Corps of Engineers under 622720D048, "Industrial Operations Pollution Control (6.2 Exploratory Development)," Work Unit U10, "Alternatives for Hazardous Material Removal." The technical reviewer was Chris Vercautren, Industrial Operations Command.

The work was performed by the Environmental Processes Branch (CN-E) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Michelle J. Hanson. Dr. Leo R. Gizzi and Dr. Roger Schneider are contractors with Rho Sigma Associates, a scientific and engineering consulting firm. The technical editor was Linda L. Wheatley, Information Technology Laboratory. Dr. Ilker Adiguzel is Chief, CN-E, and Dr. John Bandy is Chief, CN. The associated Technical Director was Gary Schanche, CV-T. The Acting Director of CERL is William D. Goran.

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1 Introduction

Background

The Construction Engineering Research Laboratory (CERL) has had a research and development (R&D) effort in progress since Fiscal Year 1997 (FY97) to develop alternatives for safe, economic, and environmentally benign assessment, decontamination, and disposal of excess ordnance production facilities. These buildings may have considerable quantities of residual energetic materials (EMs) and asbestos, and may also be structurally unsound. The EMs in these facilities include finished military explosives, propellants, and pyrotechnics as well as precursors to these materials.

An explosion occurred during scheduled demolition of an inactive building at the Sunflower Army Ammunition Plant (SFAAP) on 10 July 1996. The building was intentionally set afire as the least hazardous way of destroying the structure. However, residual contamination, determined to be nitrocellulose (NC), caused the building to explode and substantially spread asbestos and other building materials to the surrounding area.

Numerous buildings at approximately 20 inactive plants in the U.S. Army Materiel Command (AMC) are designated as excess and slated for destruction. The SFAAP incident resulted in a need to document contaminated facilities at inactive AAPs to determine technologies for safely removing and disposing of these facilities while protecting the environment.

One of the first steps in properly disposing of an EM production building is to assess its contamination status. The presence of explosive materials, and the type and amount of those materials, are important considerations when selecting a disposal alternative. Several methods are available for identifying EMs; however, these have not been evaluated for use in U.S. Army production facilities. The existing technologies are designed primarily to detect EMs as explosive devices in luggage, packages, and various containers. To be useful at U.S. Army facilities, these technologies must be evaluated for their ability to detect EMs on various surfaces and sub-surfaces of a building, and be demonstrated in a practical EM production environment (active or layaway).

Objective

The objective of this work was to evaluate various EM detection devices for use at excess ammunition production facilities.

Approach

Manufacturers of EM detection equipment were contacted to determine the status of the current technology and to solicit interest in this evaluation. Four technologies were selected for testing. Selection was based on applicability, cost, and interest in study participation.

A test protocol was developed for use in evaluating the various detection devices. This protocol included the identification of EMs of concern, types of buildings to use for the evaluation, and building characteristics. The protocol also addressed a means of determining the accuracy of results.

The four selected technologies were tested at the Radford Army Ammunition Plant (RAAP) in Virginia. Facilities selected as test sites reflected as much variation in EM usage, construction, building materials, and other conditions as possible. Representatives from each company and a CERL representative spent 1 day onsite at RAAP, evaluating their detection devices following the developed protocol. The same facilities were used to test each piece of equipment.

Mode of Technology Transfer

Findings from this study will be incorporated into ongoing research efforts involving the assessment, decontamination, and disposal of excess EM processing buildings at U.S. AAPs.

Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for Standard International (SI) units is provided below.

SI conversion factors		
1 sq in.	=	6.452 cm^2
1 lb	=	0.453 kg

2 Selection of Evaluated Instruments and Materials

Instruments Selected for Evaluation

Four manufacturers of instruments that detect EMs visited RAAP to demonstrate the capabilities of their products. The companies were Barringer Instruments, Thermedics Detection, Inc., Intelligent Detection Systems (IDS), and Ion Track Instruments. Table 1 lists each company and the demonstrated instruments commercially available at the time of the study.

Table 1. EM detection instruments demonstrated at RAAP.

Manufacturer	Instrument
Barringer Instruments, Warren, NJ	IONSCAN 400B
Ion Track Instruments, Wilmington, MA	VaporTracer
Ion Track Instruments, Wilmington, MA	ITEMISER
Thermedics Detection, Chelmsford, MA	EGIS II
IDS, Ottawa, ON, Canada	EVD 3000

Ion-mobility Spectrometers

The Barringer IONSCAN 400B and Ion Track VaporTracer and ITEMISER are ion-mobility spectrometers, also known as plasma chromatographs. Ion-mobility spectrometers consist of an ion source at atmospheric pressure (reaction region) and an ion-drift spectrometer (drift region). In the ion source region of the spectrometer, EM molecules are converted into negatively charged ions. In the drift region, the ions migrate through an electric field. Drift time is shorter for lighter ions and longer for heavier ions; that is, drift time is proportional to ion mass. The ions are eventually detected by colliding with an electrometer plate, producing a measured current. Each energetic compound has a unique plasmagram.

Barringer Instruments uses an air sampler that is a hand-held, battery-operated vacuum, resembling a flashlight. It collects EMs on a cloth swab, which is inserted into the IONSCAN 400B for analysis. The footprint of the IONSCAN is approximately 15 sq in. For the purposes of this study, the instrument was set up in a laboratory at RAAP. Cloth swab samples collected in the field were brought to the laboratory for analysis.

Ion Track's ITMS VaporTracer is a hand-held portable instrument used for detecting and analyzing air samples. It draws in air samples from the location being tested and then performs the ion-mobility spectrometric analysis. The Ion Track ITEMISER, a bench instrument, receives for analysis EMs collected on cloth swabs. The ITEMISER, which has a 21-sq in. footprint, was set up in a laboratory at RAAP. Swab samples collected in the field were brought to the laboratory for analysis.

Gas Chromatograph with Chemiluminescence Detector

Thermedics Detection's EGIS II uses a high-speed gas chromatograph (GC) with a chemiluminescence detector. Air samples are collected with a hand-held battery-operated vacuum aspirator similar to that used with Barringer's IONSCAN 400B. It collects EMs from vapors or particulate matter onto a filter card. The card is then placed into the EGIS II instrument intake port. These same filter cards are used as swab wipes for surface sampling. The sample inlet services two high-speed GC columns, one at 400 °C and the other at 800 °C. Helium carrier gas transports the EM molecules through pyrolysers, which produce detectable nitric oxide (NO). A chemiluminescence reaction between NO and ozone (O_3) produces an infrared photon, which is captured by a photomutiplier. The GC retention times and detector outputs are used to determine the specific EMs. The EGIS II unit weighs approximately 165 lb and uses two tanks of helium gas. A cart was provided by the company for movement of the system. The instrument was set up in a laboratory at RAAP, requiring approximately 900 sq in. of floor area. Swab samples were brought to the laboratory for analysis.

EM Vaporizer

The IDS EVD 3000 is a hand-held portable instrument that vaporizes (decomposes) EM material from a metal screen that is contaminated by rubbing with a swab or cotton glove used to accumulate the sample. The instrument uses a sensitive electrochemical sensor for NO_2. Chromatography is accomplished with selective adsorption membranes. The EVD 3000 gives a positive/negative result. If an EM is detected, the instrument responds positively; if no EM is detected, it displays a negative output. The instrument detects chemicals with decomposed nitrogen-containing groups ($-NO_x$), detecting oxides of nitrogen. The EVD 3000 does not identify specific EMs (e.g., trinitrotoluene [TNT], cyclotrimethylene trinitramine [RDX], nitroglycerine [NG]), it just detects that an EM is present.

Additional information about each of these technologies can be found in Appendices A – D to this report.

EM Selection Criteria

To maintain a manageable level of evaluation parameters, a limited number of EMs were selected for this study:

- NC
- NG
- nitroguanidine (NQ)
- RDX
- Cyclotetramethylene tetranitramine (HMX)
- TNT
- dinitrotoluene (DNT)

These EMs, in various combinations, are commonly found in Department of Defense propellants and explosives. They are also common to RAAP production areas. However, the number of potential EMs that are detected by the instruments evaluated in this study are not limited to the seven listed.

3 Sites Selected for Instrumental Analysis

Prior to the evaluation, researchers visited RAAP to select building sites for evaluating instruments capable of detecting EMs. Factors considered included building construction type, likely EMs present, and building status. Buildings were selected to provide as wide a variety of test situations as possible.

Table 2 shows the buildings selected as test sites. Column headings in the table include building status, type of anticipated EM contamination, and other possible EM contamination. Eight buildings were selected for evaluation. The buildings were primarily wooden structures with concrete or wooden floors. Some contained a significant amount of equipment, whereas others were completely empty. Most have been in use for at least 25 years. Some of the buildings are active processing facilities, while others are on standby in a 3X condition of contamination (i.e., cleaning has removed surface contamination, but significant amounts may remain in less obvious places). In most cases, only one principle EM is associated with the building, but numerous unknown EMs are possibly present.

Table 2. Buildings selected for analysis with EM detection instruments.

Building Number	Building Name	Status	Anticipated EM	Other Possible
4932	DNT Grinding and Screening	Active	DNT	None Likely
3692/C-6	High Energy Mix House, Bay 1	Active	NC, NG, NQ RDX, HMX	Unknown
3609/C-3	Multibase Ingredient Storehouse	Active	NC, NG, NQ	Unknown
3026	NC Final Wringer	Active	NC	None Likely
4912-47	Multibase Forced Air Dry House	Standby/3X	NG	Unknown
7140	Triple Base Sorting and Blending	Standby/3X	NC, NG, NQ	Unknown
9500	TNT Nitration and Purification	Standby	TNT	DNT
9503	TNT Finishing and Packing	Standby/3X	TNT	DNT

Researchers selected specific spots in each building as required sampling locations so that direct comparisons of the results could be made. Additionally, each instrument manufacturer was provided the opportunity to select additional sampling locations that were of interest to them.

Building Descriptions

Descriptions of each of the selected buildings follows.

4932 DNT Grinding and Screening

Building 4932 is an old wooden two-story structure with a concrete floor. The inside of the building had been painted at some time. The floor is painted with conductive black paint. The building contains equipment to grind DNT and, at the time of the study, contained numerous containers of DNT. The building is active and not barricaded.

3692/C-6 High Energy Mix House

Building 3692 is an old wooden one-story structure with two bays separated by a reinforced concrete wall. The inside of the building is painted. It has a concrete floor painted with conductive black paint. The building contains two sigma blade stainless steel mixers for processing high-energy propellants. The building is active and barricaded.

3609/C-3 Multibase Ingredients Storehouse

Building 3609 is an old wooden one-story, one-room structure built on a concrete floor. The interior is painted. The floor had also been painted with conductive black paint. The building is active but was empty during this study. It is not barricaded.

3026/NC Final Wringer

Building 3026 is an old wooden two-story structure built on a concrete floor. The interior is painted. Among other equipment, it contains a telifer system to transport metal cans of water-wet NC. It is an active building and not barricaded.

4912-47/Multibase Forced Air Dry House

Building 4912-47 is an old one-story, one-room wooden structure. The interior walls and ceiling of the building are covered in galvanized sheet metal (perhaps tin) with many seams. The seams have been sealed with some type of sealant and tape, which is in poor condition. The floor is covered with lead and the building is barricaded. It is empty and in a 3X standby condition.

7140/Triple Base Sorting and Blending

Building 7140 is an old wooden one-story, one-room structure built on a concrete floor. The floor is painted with conductive black paint. The building is being used for storage of propellant drying trays and equipment used for blending triple base (TB) stick propellants. The building is in a 3X standby condition.

9500/TNT Nitration and Purification

Building 9500 is a concrete building (floors, walls, ceiling). The walls and ceiling are painted white, and the floor is unpainted. The building has an earthen cover that is used as a barricade. It contains a significant amount of equipment (kettles for nitration and separation) used to nitrate and purify TNT and DNT. It is in standby but has not been cleaned to a 3X condition.

9503/TNT Finishing and Packing

Building 9503 is a concrete building (floors, walls, ceiling). The walls and ceiling are painted white, and the floor is unpainted. The building has an earthen cover that is used as a barricade. The building is being used for storage of equipment and materials. It contains some remnant TNT packing equipment. The building is in a 3X standby condition.

Confirmatory Analysis

Before the instrumental evaluations, swab samples were taken in various places and analyzed to determine the type of EM(s) present in each building.

The EXPRAY™ chemical bomb detection kit was used in the selection of the sampling sites within the test buildings. This kit contains Chemical/Bomb Detection Sprays that distinguish between certain nitroaromatics, nitrate esters, nitramine compounds, and inorganic nitrates. Specifically, the kit includes a set of three chemical color reagents packaged as aerosol spray cans labeled

EXPRAY™ 1, 2, and 3. Product description sheets and material safety data sheets (MSDSs) are included in Appendix E of this report.

During the visit to RAAP, the EXPRAY™ kit was demonstrated to differentiate TNT and DNT (polynitroaromatics), and also to differentiate these from organic nitrate esters and nitramines. Inorganic nitrates were also differentiated. The kit was shown to be specific for TNT and DNT, but non-specific for nitrate esters and nitramines (NC, NG, RDX, HMX show a similar reaction). It was quite useful in determining specific contaminated locations, and in selecting the sampling locations in buildings used for evaluation of the instruments.

Table 3 shows the results of evaluating the EXPRAY™ bomb detection kit on known EMs in the laboratory. Similar results were obtained in tests conducted in the contaminated buildings described in the previous section.

Table 3. Results of evaluation of EXPRAY™ chemical bomb detection kit.

	EXPRAY Evaluation Results*		
EMs tested	**Spray 1**	**Spray 2**	**Spray 3**
NC	(-)	(+) pink	N/A
NG/DEGDN** mix	(-)	(+) pink	N/A
RDX	(-)	(+) pink	N/A
HMX	(-)	(+) pink	N/A
NQ	(-)	(-)	(+) pink
TNT (dilute)	(+) pink	N/A	N/A
TNT (concentrate)	(+) brown/purple	N/A	N/A
DNT	(+) blue/green	N/A	N/A
KNO_3***	(-)	(-)	(+) pink

*(-) Negative reaction; (+) positive reaction and resulting color

** DEGDN = diethyleneglycoldinitrate

*** KNO_3 = potassium nitrate

4 Discussion of Results

The following sections summarize results from both the detection of known (control) EMs and the EMs detected at specific locations at RAAP with each instrument.

Use of Known (Control) EMs

During the instrument evaluation, several tests were conducted using control EMs in the laboratory. The purpose of these tests was to verify that the instruments could differentiate various EMs. Because it does not have the ability to differentiate, the IDS EVD 3000 was not tested in the laboratory. Table 4 summarizes the control tests conducted and the results obtained.

The Barringer IONSCAN, Thermedics EGIS II, and the Ion Track VaporTracer and ITEMISER instruments, in their configurations evaluated at RAAP, were not capable of detecting NC or DEGDN.

The Barringer IONSCAN, and Ion Track VaporTracer and ITEMISER instruments were capable of detecting NQ. It is likely that the EGIS II could be set-up to detect NQ based on its capability to detect other EMs.

Table 4. Instrumental detection of known (control) EMs.

Control EMs	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer	ITEMISER
NC	Variable	(-)	---	(-)	(-)
NQ	(+)	(-)	---	(+)	(+)
NG/DEGDN (50/50) in Methanol	---	NG	---	---	---
Mixture in Acetonitrile*	NG/RDX/HMX	NG/RDX	---	NITRO/RDX/HMX	NITRO/RDX

(+) positive result; (-) no alarm; --- not tested

*Mixture is NG/RDX/HMX/DEGDN/ethyl nitratoethylnitramine (ET NENA)/methyl nitratoethylnitramine (ME NENA)/AKARDITE II

The EGIS II, VaporTracer, and ITEMISER instruments did not differentiate 2,4- and 2,6- DNT. The instruments registered both EMs as DNT. It is likely that EGIS II can be calibrated to detect and differentiate the two isomers.

In analyzing a complex mixture of EMs in acrylonitrile, all of the instruments were capable of detecting NG and RDX. EGIS II in its current configuration does not differentiate RDX and HMX. Both the IONSCAN and VaporTracer instruments detected HMX. The ITEMISER can differentiate RDX from HMX if sufficient “drift” time is allowed. The instrument might miss detecting HMX in cases where high concentrations of RDX are present. The complexity of the mixture and presence of solvent did not appear to interfere with the analyses.

Comparison of EM Detection Results

The following tables show a comparison of the EM detection results from each of the instruments evaluated in this study. Samples were taken by each manufacturer during their visits to the location and analyzed in their instruments. Although the samples were taken from the same area, most of the comparisons are not with the exact same sample — each manufacturer obtained a separate sample from each location.

In each building, both Ion Track instruments were used. The VaporTracer instrument was used to analyze air samples and the ITEMISER was used to analyze the swab samples. The VaporTracer could be used to evaluate swab samples by shaking or scraping the dust into the intake stream of the instrument.

Initially, neither Ion Track instrument was calibrated for the detection of NQ. However, a sample of NQ in the laboratory was used to quickly calibrate the VaporTracer and ITEMISER. Both instruments were then capable of detecting NQ.

The instruments evaluated are very sensitive to EMs. As a result, the swab samples taken at each location were re-swabbed before testing in the instruments. This step reduced the concentration of EM present on the test sample to keep the instrument from being saturated. In some cases, the amount of an EM detected was very small on the re-swab. In these cases, the original concentrated swab sample was used in the detection test and a note was made.

Building 4932

This building contains equipment that is used to grind DNT and also contains numerous containers of DNT. Therefore, all instruments would be expected to identify the presence of DNT throughout this facility.

As shown in Table 5, all of the instruments detected DNT in various places in the building. The EVD 3000 instrument gave positive alarms in appropriate places. The EGIS II instrument unexpectedly detected NG in two situations. The reason for this detection is unknown, but it was not expected that NG would be a contaminant in this building.

Air samples taken from this building saturated the EVD 3000 instrument's air intake. The instrument could not be decontaminated in a reasonable amount of time. Therefore, no additional air samples were taken with the EVD 3000 instrument.

Only the IONSCAN 400B differentiates 2,4-DNT and 2,6-DNT.

Table 5. Comparison of EM detection results at Bldg 4932 – DNT grinding.

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer and ITEMISER
Air				
10 seconds	---	---	---	DNT
15 seconds	DNT	---	---	---
30 seconds	---	DNT/NG	---	---
60 seconds	No Alarm	---	---	---
2 minutes	DNT	---	---	---
Swab				
Top of sprinkler	2,4 DNT	DNT	---	DNT
Top of shaft housing	2,4 DNT	DNT/NG	(+)	DNT
Floor, back of grinder	2,4 DNT	DNT	(+)	DNT
Top of window ledge	2,4 DNT	---	---	DNT
Lip of DNT container	---	---	(+)	---
(+) = positive result --- No sample taken				

Building 3692

The high energy mix house is used to mix and process high energy propellants. Because of this, the building is likely contaminated with both NG and RDX/HMX.

As Table 6 shows, NG and RDX/HMX were the main EMs detected by all instruments. The EVD 3000 detected EMs in appropriate places. NC would likely have been detected if the instruments had been capable. The fact that RDX and HMX were not detected consistently may be a result of having different samples for each analysis. Also, the contaminates could have been widely but not uniformly distributed in the building. The Ion Track ITEMIZER detected RDX in two places without specifically identifying HMX, which could be related to the instrument configuration at the time of the analysis.

With both the VaporTracer and the ITEMISER instruments, detection of some EMs yielded a plasmagram peak that was labeled NITRO. The manufacturer considered this peak to be NG and/or NC, which were considered indistinguishable with the instrument at the time. Subsequent testing at the laboratory indicated that neither instrument could detect NC. Therefore, the NITRO peak is assigned to NG.

The Ion Track ITEMISER had difficulty distinguishing between RDX and HMX when using the building swab samples. RDX is more mobile through the rubber diaphragm of the Ion Track instruments and imposes a strong peak in the plasmagram. Either instrument readily detects RDX. HMX, on the other hand, is slow to migrate through the diaphragm and, although it provides a distinct peak on the plasmagram, it is only detected if sufficient charge remains on the detector upon its arrival. In addition, sufficient time must be allotted during the analysis to provide for the slow migration. In many cases, HMX was not easily detected in laboratory tests when combined with other EMs (particularly RDX). Sufficient migration time and rerunning the instrument cycle would need to be effected for the HMX to be detected.

Table 6. Comparison of EM detection results at Bldg 3692 – High energy mix house.

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer & ITEMISER
Air				
10 seconds	---	---	---	NITRO
2 minutes	NG/RDX	---	---	---
Swab				
Top of pipe	RDX/HMX	NG/RDX	---	NITRO/RDX
Lid of mixer	NG	NG	(+)	NITRO
Gear housing	RDX/HMX	---	---	NITRO
Floor, front of mixer	NG/RDX/HMX	NG	(+)	NITRO
Floor, behind mixer	NG/RDX/HMX	---	---	NITRO
Wall, left side of mixer	RDX/HMX	---	---	NITRO/RDX
(+) = positive result --- No sample taken				

Building 3609

Building 3609 (C-3) was once a storage house for multiple ingredients for propellant. It was empty at the time of this study. Detection of NG and RDX/HMX was expected in this building. Table 7 shows the results from sampling analysis.

The IONSCAN instrument detected NG and RDX/HMX in various places in the building. Unfortunately, the building was washed down after the IONSCAN instrument test. The floor and walls were still wet at the time of the EGIS II sampling, and both the EVD 3000 and Ion Track instruments were tested the week following the wash down. Washing the building may have removed solid particulate matter like RDX/HMX prior to testing by the other instruments.

All instruments consistently detected NG, but not as uniformly as might be expected. The EVD 3000 instrument detected EMs in appropriate places.

Table 7. Comparison of EM detection results at Bldg 3609 (C-3) – Multibase ingredient storage.

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer and ITEMISER
Air				
2 minutes	NG	---	---	NITRO
Swab				
Top of sprinkler head	RDX/HMX	NG/DNT	(+)	NITRO
Floor, right, back under radiator	HMX	NG	---	NITRO
Sill near floor	NG	---	---	NITRO
Side wall face	RDX/HMX	---	---	NITRO
Desk top	NG/HMX	NG	(+)	NITRO
(+) = positive result --- No sample taken				

Building 3026

Building 3026 contains a telifer system used to transport metal cans of water-wet NC. Therefore, detection of NC was expected inside the facility. Table 8 shows the results of sampling analysis. None of the instruments was capable of detecting NC. This was corroborated by tests in the laboratory involving known EMs.

Table 8. Comparison of EM detection results at Bldg 3026 – NC final wringer.

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer and ITEMISER
Air				
2 minutes	No Alarm	---	---	NITRO (Trace)
Swab				
Top of control panel	Problems Analyzing	No Samples Taken	(-)	No Alarm
Floor, step near entrance			---	No Alarm
NC chute			(+)	No Alarm
Top of monorail			---	NITRO
Vertical I-beam surface			---	NITRO
Outside lip telifer tub			(-)	---
Inside telifer tub			(+)	---
(+) = positive result --- No sample taken				

Building 4912-47

Because Building 4912-47 contained NG propellants, identification of NG and RDX/HMX was expected in most areas. Table 9 shows the results of sampling analysis. Most of the instruments consistently detected NG. The IONSCAN did not identify NG in all of the sampled areas. The IONSCAN 400B, EGIS II, and ITEMIZER generally detected RDX and HMX. The EVD 3000 gave positive alarms in appropriate places. The presence of TNT or DNT as detected by IONSCAN and EGIS in this building is questionable.

Table 9. Comparison of EM detection results at Bldg 4912-47 – Forced air dry house (3X).

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer and ITEMISER
Air				
10 seconds	---	---	---	NITRO
15 seconds	NG	---	---	---
60 seconds	NG/RDX	---	---	---
2 minutes	NG/RDX/HMX	NG	---	---
Swab				
Back wall	NG	NG	(+)	NITRO
Floor, back of building	RDX/TNT	NG	---	NITRO/RDX
Duct, inside top	RDX	NG/RDX	---	NITRO
Floor, right back corner	RDX/TNT	NG/RDX/DNT*	---	NITRO/RDX
Duct, outside top	RDX	---	---	NITRO
Window face	NG/RDX/HMX	NG/RDX	(+)	NITRO/HMX
(+) = positive result --- No sample taken * Full strength swab sample used rather than a less concentrated re-swab of the full strength sample.				

Building 7140

Building 7140, a TB sorting and packing facility, was not in use. It is in standby condition, having been cleaned to a 3X level. Table 10 shows the results of sampling analysis. NC was probably present as propellant dust but was not detectable by the instruments with their current capability. NQ may have been present also as part of the TB propellants but was likely encapsulated in the NC/NG binder. In this configuration, the instruments might not recognize the presence of NQ. The instruments consistently detected NG in this building. EVD 3000 gave positive alarms in appropriate locations.

Table 10. Comparison of EM detection results at Bldg 7140 – Triple base sorting and packing (3X).

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer and ITEMISER
Air				
2 seconds	---	---	---	NITRO
2 minutes	NG/RDX	NG	---	---
Swab				
Sprinkler, top of pipe	NG	NG	(+)	NITRO
Entrance ledge	NG	---	---	NITRO
Plastic box for blending	NG	NG	(+)	NITRO
Floor, mid-room	NG	NG	---	NITRO
Inside procedure box on wall	NG	---	---	---
Wall surface	NG	NG	---	NITRO
(+) = positive result --- No sample taken				

Building 9500

Building 9500 is also in standby condition, but has not been cleaned. This building contains equipment used for nitration of toluene and purification of TNT and DNT. Therefore, detection of these materials was expected. Table 11 shows the results of sampling analysis.

The instruments consistently detected TNT and DNT, and the EVD 3000 gave positive alarms in appropriate locations. Detection of NG by the IONSCAN 400B was not expected; however, it is possible that the hand-held vacuum for air sampling may have become contaminated. Detection of RDX is a questionable result.

Table 11. Comparison of EM detection results at Bldg 9500 – TNT nitration/purification (3X).

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer & ITEMISER
Air				
10 seconds	---	---	---	TNT/DNT
2 minutes	NG/RDX	---	---	---
Swab				
Top of kettle (#8)	TNT	TNT/DNT	(+)	TNT/DNT
Floor sample, front of control room	TNT/2,4 DNT	TNT/DNT/NG*	---	TNT/DNT
Top of light fixture	No Alarm	---	---	TNT
Bottom of nitrator lid (#8)	TNT/2,4 DNT	---	---	TNT
Wall surface, control room	TNT	TNT/DNT	(+)	TNT/DNT

(+) = positive result

--- No sample taken

* Full strength swab sample used rather than a less concentrated re-swab of the full strength sample.

Building 9503

Building 9503 is in standby condition and has been cleaned to a 3X level. The building contains equipment used to pack TNT. Detection of TNT is likely throughout this facility. Table 12 summarizes the test data. The EVD 3000 gave positive alarms in appropriate places. The EGIS II detected TNT appropriately; however, it also detected NG. NG is not likely to have been present; however, the hand-held vacuum for air sampling may have become contaminated. Detection of RDX in this building is also unexpected; however, the sensitivity of the IONSCAN and EGIS instruments could have detected trace quantities of these materials.

Table 12. Comparison of EM detection results at Bldg 9503 – TNT finishing/packing (3X).

Sample	IONSCAN 400B	EGIS II	EVD 3000	VaporTracer and ITEMISER
Air				
10 seconds	---	---	---	TNT
2 minutes	RDX/TNT	TNT/NG	---	---
Swab				
Conveyor rolls under hopper	TNT	TNT	(+)	TNT
Wall surface	TNT	---	(+)	TNT*
Floor, next to wall	TNT/RDX	TNT/DNT/NG	(-)	TNT
Top of fume duct	TNT/RDX	TNT/RDX	---	TNT
Top of fume duct (4)	---	TNT/RDX/NG	---	---
Conveyor belt	TNT/RDX	TNT/RDX	---	TNT

(+) = positive results

--- No sample taken

* Full strength swab sample used rather than a less concentrated re-swab of the full strength sample.

5 Instrument Pricing and Utility

Table 13 summarizes the estimated cost of the EM detection instruments evaluated in this study. The table also includes an instrument rating indicating the ease of use, ranging from easy to somewhat difficult. The tabletop models (IONSCAN 400B, EGIS II, and ITEMISER) are priced in the range of $40,000 to $65,000. The more portable models (EVD 3000 and VaporTracer) are priced in the range of $20,000 to $34,000.

These devices are expected to have long service lives. However, most of the units in operation today have insufficient service histories to predict maintenance requirements and a true useful life expectancy. The manufacturers anticipate few problems because of the low number of moving parts involved. Regular maintenance and calibration are recommended to keep the instruments accurate and in good working order.

Table 13. Summary of EM detection instrumentation pricing and utility.

Instrument Manufacturer	Model	Estimated Price*	Ease of Use**
Barringer Instruments	IONSCAN 400B	$43 K	(3)
Thermedics Detection	EGIS II	$65 K	(4)
Intelligent Detection	EVD 3000	$20 K	(2)
Ion Track	VaporTracer	$34 K	(2)
Ion Track	ITEMISER	$40 K	(3)

* Pricing includes the instrument and the required startup materials.

- The IONSCAN 400B pricing includes a maintenance kit, air sampler, disposables, and training at their New Jersey location.
- The EGIS II pricing is for the instrument and numerous items itemized in Appendix B. The pricing does not include training and installation of the instrument.
- For the EVD 3000 hand-held unit, the package includes batteries, case, sample screens, and gloves.
- For the VaporTracer hand-held unit, the package includes the explosives module, two batteries, cables, supplies, computer, and onsite training.
- The ITEMISER includes 6 month’s consumables, and onsite installation and training.

** Ease of Use is classified as:

(1) Extremely Easy — No training or technical knowledge needed.
(2) Easy — Some training needed. Operator does not need technical knowledge.
(3) Moderately Easy — Training needed from manufacturer. No technical knowledge required.
(4) Difficult — Training needed from manufacturer. Some technical knowledge desired.
(5) Very Difficult — Training required from manufacturer. Technical knowledge required.

6 Conclusions

All of the instruments evaluated in this study are capable of detecting EMs. They are designed and were demonstrated to be very sensitive to small levels of contamination. Instrument performance was not hindered by either the conditions at RAAP or the building material substrate.

Each instrument had superior qualities, as well as features less suited for use in field work like that experienced at RAAP. Overall, the Ion Track ITMS VaporTracer is well suited for applications described in this report. The VaporTracer has the ability to adequately detect low levels of EM with accuracy and reproducability. In conjunction with its portability, sensitivity, EM specificity with visual read-out, ease-of-use, cost, and ease of decontaminating after being saturated, it has the best combination of characteristics for field applications in EM production facilities.

In a laboratory or more stationary environment, the IONSCAN 400B, EGIS II and ITEMISER are all capable of detecting EMs from samples obtained in the field. Each instrument has pros and cons in its performance and other characteristics (cost, ease-of-use, decontamination after saturation, etc.). Selection of one or the other of these instruments should be based on individual requirements.

The EVD 3000 hand-held instrument was capable of detecting low levels of EMs. It was not designed to be specific in its identification but is more suited to general detection of very low levels of EMs. For this reason it can more easily be saturated by EMs and require long decontamination times. In applications where portability is needed without any EM specificity, and where very low levels of contamination are being sought, the EVD 3000 would be a suitable candidate.

References (Uncited)

Schneider, R.L., and C.M. Spooner, "Detection, Assessment and Hazards Mitigation of Asbestos Contaminated With Energetic Materials (Explosives, Propellants and Pyrotechnics), Contained in Building Material," USACERL Contract #DACA88-97-M-0084 and #DACA88-97-M-0085, USACERL, Champaign, IL, 31 December 1997.

"Protocol for the Characterization of Explosives-Contaminated Sites," DREV-R-9721, Defense Research Establishment, Center for Defense Research, Valcartier, Quebec, Canada, April 1998.

List of Acronyms and Abbreviations

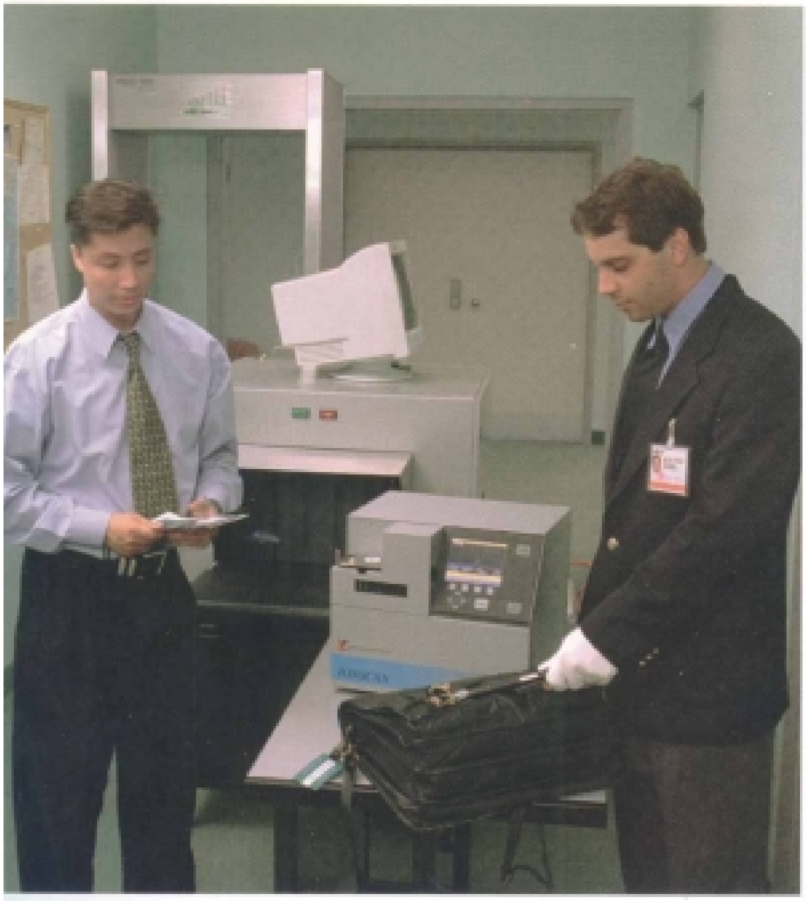
AAP	Army Ammunition Plant
AMC	Army Materiel Command
CERL	Construction Engineering Research Laboratory
DEGDN	diethyleneglycoldinitrate
DNT	dinitrotoluene
EM	energetic material
ET NENA	ethyl nitratoethylnitramine
FY	fiscal year
GC	gas chromatography
HMX	cyclotetramethylene tetranitramine
IDS	Intelligent Detection Systems
KNO_3	potassium nitrate
ME NENA	methyl nitratoethylnitramine
MSDS	material safety data sheet
NC	nitrocellulose
NG	nitroglycerine
NITRO	Ion Track abbreviation for nitroglycerine
NO	nitric oxide
NO_2	nitrogen dioxide
NQ	nitroguanidine
O_3	ozone
R&D	research and development
RAAP	Radford Army Ammunition Plant
RDX	cyclotrimethylene trinitramine
SFAAP	Sunflower Army Ammunition Plant
TATP	tri-acetone tri-peroxide (tricycle acetone peroxide)
TB	triple base (propellant)
TNT	2,4,6-trinitrotoluene

Appendix A: Barringer Instruments, Inc., Product Description Sheets

BARRINGER

IONSCAN® 400B

The World Leader in Trace Explosives and Drug Detection



Applications

Corrections
Airport Security
Customs
Site Security
Drug Interdiction
Coast Guard
Forensics

The IONSCAN® Model 400 has set the performance standard for explosives and narcotics trace detection instruments for years. The IONSCAN® has consistently demonstrated its effectiveness in detecting trace amounts of explosive or narcotic substances in numerous field deployments, serving a wide variety of law enforcement and security applications.

Now the IONSCAN® Model 400 is available in a smaller, lighter and more user friendly configuration. The new Model 400B maintains the same performance characteristics of high sensitivity and reliability that have made the IONSCAN® the benchmark in trace narcotics and explosives detection, while increasing overall ease of use. The 400B offers a single module package, brilliant color LCD, and simplified operational functions.

Appendix B: Thermedics Detection, Inc., Product Description Sheets


TDX
Sensing the Future
We approach safety with
INNOVATION
New from the world wide leader in explosive trace detection.
Introducing the new EGIS®
Models:
EGIS II
EGIS III
EGIS IV
Advantages:
• Cost effective
• Maintains high passenger throughput
• Minimal operator training
• Simple to operate
• Simultaneously detects explosives and ICAO taggants
TDX
EGIS II
THERMEDICS
DETECTION

TDX

EGIS® II / EGIS III / EGIS IV

New - from Thermedics Detection Inc. the world wide leader in explosive trace detection equipment that brought you the patented technology of EGIS - a new line of portable, bench-top explosives detection systems EGIS II, III and IV to complement the family of EGIS products.

Specifications:	EGIS II	EGIS III	EGIS IV
Technology	High Speed GC	High Speed GC	High Speed GC
Detector	Chemiluminescense	Chemiluminescense	Chemiluminescense
Explosives Detected	EGDN, NG, DNT, TNT, PETN, RDX and ICAO taggants.	EGDN, NG, DNT, TNT, PETN, RDX and ICAO taggants.	EGDN, NG, DNT, TNT, PETN, RDX and ICAO taggants.
Lower Detectable Limits	300 pg	100 pg	20 pg
False Alarm Rate	Below 1% for typical luggage screening	Below 1% for typical luggage screening	Below 1% for typical luggage screening
Analysis Cycle	12 - 15 seconds	15 - 18 seconds	15 - 18 seconds
*Sample Inlet	Direct desorb inlet for sample wipes	Direct desorb inlet for sample wipes	Direct desorb inlet for sample wipes
*Sampling Method	Collection of explosive particles by wiping	Collection of explosive particles by wiping	Collection of explosive particles by wiping
Carrier Gas	Helium or Hydrogen	Helium or Hydrogen	Helium
Display	LCD	Color LCD	Color LCD
Alarm Display	Audible, LCD and LED	Audible, LCD and LED	Audible, LCD and LED
Operational Temp Range	0 - 40 °C	0 - 40 °C	0 - 40 °C
Storage Temp Range	-10 - 50 °C	-10 - 50 °C	-10 - 50 °C
Operational Humidity Range	5 - 95% non condensing	5 - 95% non condensing	5 - 95% non condensing
Dimensions (Inches)	18.5H x 29D x 28.5W	18.5H x 29D x 28.5W	18.5H x 29D x 28.5W
Weight	165 lbs	165 lbs	165 lbs
Certification	TUV Product Service, GS Mark and CE	Pending	Pending

Optional Configuration:

- Model 300 sampler with re-useable Coil Collector for direct air and vacuum sampling.
- Model 400 sampler with disposable sample wipes for direct air and vacuum sampling.

Manufacturer reserves the right to change specifications of the product without notice.

THERMEDICS DETECTION

Thermedics Detection Inc.
220 Mill Road
Chelmsford, Massachusetts 01824

Phone: 978-251-2000
Fax: 978-251-2010
email: sales@tdxinc.com

P.N. 414638 Rev. B

Appendix C: Intelligent Detection Systems, Inc., Product Description Sheets

EVD-3000

FOR HANDHELD EXPLOSIVES DETECTION

Introducing the EVD-3000 Handheld Explosives Detector from IDS, manufacturer of some of the most advanced chemical detection systems in the world.

The EVD-3000 is the world's first and most recognized portable explosives trace detector with comprehensive explosives detection capabilities. Ready to operate in only 60 seconds, and providing a response in 15 seconds, the EVD-3000 is the only handheld detector capable of detecting plastic and high-vapor pressure explosives including taggants. If portability, quick detection and clear results are crucial, then this is the explosives detection system needed. The EVD-3000 detects both residues and vapors, allowing for non-invasive searches of luggage, mail, vehicles, documents and containers.

- **Proven:** The EVD-3000 is the only handheld detector capable of detecting plastic and high-vapor pressure explosives—giving clear results you can trust.
- **Flexible power sources:** The EVD-3000 offers the choice of a 12 volt DC rechargeable battery pack, making it convenient to use in virtually all application environments.
- **Sensitive and selective:** The EVD-3000 can detect minute traces of C-4, TNT dynamite, PETN, Semtex, EGDN, DMNB, RDX, EGMN and nitroglycerine.
- **Portable:** The EVD-3000 is self-contained and lightweight (less than 7 lbs.) and comes in a fully equipped, rugged carrying case—ready to use when and where needed.
- **Ease-of-use:** The EVD-3000 is ready for operation within one minute from turn on. A simple push of a button automatically activates the sampling and analysis mode. Results are displayed on an easy-to-read LCD—making the EVD-3000 ideal for all security personnel.

Operating the EVD-3000

The EVD-3000 is flexible and easy to operate, offering both vapor and particulate sampling without the use of a radioactive source or external carrier gas. Sample vapors directly via the sampling nozzle; or sample particles by inserting the sampling screen into the sampling port. This dual capability provides the ability to use the approach most suitable for the detection of the explosives of interest. The EVD-3000 starts processing samples immediately and gives results in just seconds. All results are indicated on the LCD and by a volume-adjustable audio alarm, making detection a one-step process.

INTELLIGENT DETECTION SYSTEMS

The world's first and most recognized portable explosives trace detector, the EVD-3000 is ideal for:

- Airports
- Embassies
- Border crossings
- Federal buildings
- Military installations
- Peacekeeping and armament control
- Nuclear facilities
- Courts of law
- VIP protection
- Corporate headquarters
- Banks
- Prisons
- Forensic investigations
- Railway and subway terminals
- Underground parking areas

...Worldwide

SPECIFICATIONS*

DETECTION SYSTEM	Thermo-Redox Detector No radioactive source
SAMPLING METHODOLOGY	Vapor and particle sampling
SENSITIVITY + DETECTABLE COMPOUNDS	Most military and commercially available explosives. Exact matrix available on request/ICAO taggants: DMNB EGDN O-MNT P-MNT
CONTROLS	Power switch, audio control and vapor/particulate selector
WARM-UP TIME	One minute with regular use (up to a maximum of 5 minutes after extended shutdown)
TYPICAL SAMPLE/ANALYSIS TIME	Sample: 5-10 seconds (user selectable) Analysis: 10 seconds
OPERATIONAL STATUS INDICATORS	LED indicator lights 2 x 16 character LCD for status messages
AUDIO INDICATOR	Volume-adjustable alarm with earphone
OUTPUT	RS-232 for remote control monitoring
POWER SUPPLY	12 volt DC rechargeable battery cartridge (for at least 1 hour use; 1 hour recharge time)
CARRIER GAS	None required
OPERATING + STORAGE TEMPERATURES	Operating: -5°C to +55°C (+23°F to +131°F) Storage: -5°C to +65°C (+23°F to +149°F)
WEIGHT + DIMENSIONS	Unit weight: 3 kg (6.6 lbs.) Unit dimensions (LxWxH): 51x14x11 cm / 20x5.5x4.3" Shipping weight: 10 kg (22 lbs.) Shipping dimensions (LxWxH): 54x23x37 cm / 21x 9x14.5"
WARRANTY	1 year return to depot

*Due to continuing product improvement, these specifications are subject to change.

INTELLIGENT DETECTION SYSTEMS

ANALYTICAL & SECURITY DIVISION
CANADA
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Nepean, Ontario
CANADA K2G 5X2
tel - 613 224-1061 **fax** - 613 224-2603
info@idsdetection.com
www.idsdetection.com

USA
7799 Leesburg Pike, Suite 900 North
Falls Church
Virginia, USA 22043
tel - 703 847-6788 (#89 voice)
fax - 703 847-6790

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Cedex, FRANCE
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fax - +238 619 701

UNITED KINGDOM
64 Chorley Road
Bispham, Ormskirk
Lancashire L40 3SL UK
tel - 1257 464000
fax - 1257 462878

IDS Intelligent Detection Systems Inc. develops and manufactures some of the most advanced chemical trace detection products and systems in the world. Our new-generation GC/IMS™ dual technology-based products meet and exceed industry standards and have been evaluated and accepted for use by leading regulatory bodies like the FAA, U.K. DOT and Transport Canada. IDS technology is used extensively in law enforcement, corrections, aviation and military applications.

D E T E C T T H E D I F F E R E N C E

Appendix D: Ion Track Instruments Product Description Sheets

ION TRACK INSTRUMENTS

Leaders in Detection Technology

ITMS® VaporTracer™ Portable Contraband Detector

The ITMS® VaporTracer™ Portable Contraband Detector is the latest technology available for detecting narcotics and explosives. Based on Ion Track Instruments' patented Ion Trap Mobility Spectrometer, this new hand held detector is extremely sensitive. The VaporTracer is also designed to handle demanding security environments where fast and accurate analysis is essential. The patented ITMS® detector has been field proven worldwide in the Ion Track ITEMISER® desktop instrument, and is now available for the first time in a battery powered portable configuration.

This new detector has been developed and tested with support from the D.O.D. Counter-Drug Technology Development program, acting on behalf of a consortium of U.S. Government Agencies including U.S. Customs, U.S. Coast Guard, Federal Aviation Administration and the President's Office of National Drug Control Policy. The instrument weighs 7 lbs. and is capable of detecting and identifying extremely small quantities of narcotics or explosives. The system works by drawing a sample of the vapor into the detector where it is heated, ionized, and then identified by its unique plasmagram.

The VaporTracer™ Portable Contraband Detector is easy to use with a five button keypad and LCD display. The instrument requires little operator training, and is internally calibrated with the touch of a single button.

- Lightweight - 7 lbs hand held
- Operates on 110/220 VAC, a 90 minute Fast Recharge Battery or a Six Hour Battery Pack.
- Automatic Calibration
- Self Diagnostics
- Switchable to detect either Explosives or Narcotics.
- The most sensitive portable vapor detection system available.
- Government tested and verified.
- Can be connected to ITEMISER® Contraband Detector for analysis and access to the touch screen display and on-board printer.

Data Display

The VaporTracer™ bar graph (Figure 1) indicates the strength of the alarm. For more detailed analysis, an ion signature spectrum known as a plasmagram can also be easily displayed with the use of an optional laptop computer and proprietary software (see Figure 2). The VaporTracer alarm data can be stored internally, and the plasmagram containing the date and time can be downloaded to an ITEMISER® or other computer/printer combination.

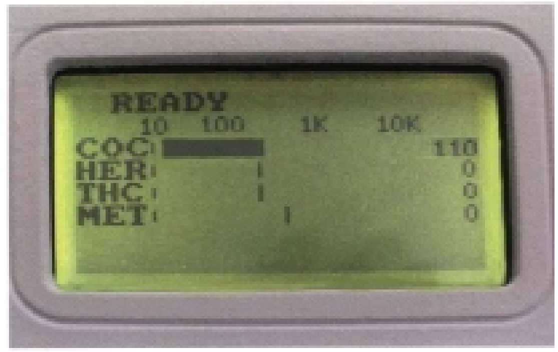

Figure 1. VaporTracer Bar Graph LCD Display

Specifications

Detector Sensitivity:	10-50 picograms of sampled material for either narcotics or explosives (proven in U.S. government and onsite tests)
Analysis Time:	Real time
Calibration:	Automatic calibration
Sample Acquisition:	Air sampling
Warm-Up Time:	Less than 30 minutes
Power Supply:	110/220 VAC 50/60 Hz mains
Options:	1.5 hour battery 6 hour battery pack with belt
Detection Type:	Ion Trap Mobility Spectrometry (ITMS®)
Integral Computer:	Internal computer with flash disk, LCD,optional external laptop
Signal Processing:	Variable integration time 1-5 seconds.
Output :	To onboard LCD bar graph or plasmagram; or a laptop computer. Positive detection signals alarm, and stores data for later analysis
Detected and Identified Substances:	
Narcotics:	Cocaine, Heroin, THC, Amphetamines, PCP and many others.
Explosives:	RDX, TNT, C4, PETN, Dynamite, Semtex, Ammonium Nitrate, HMX

WEIGHT	LENGTH	WIDTH	HEIGHT
7 lbs (3.2 kg)	16 in (40.6 cm)	5 in (12.7 cm)	9 in (22.9 cm)

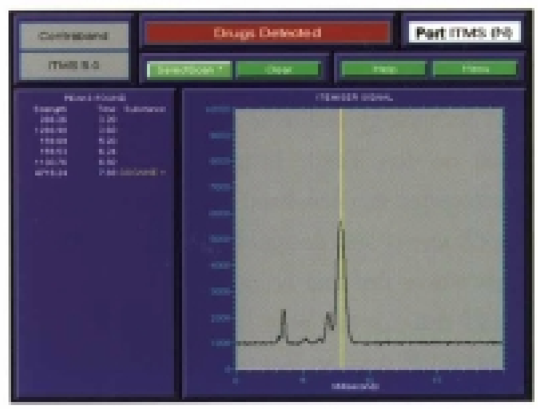

Figure 2. Laptop Alarm Screen in Narcotics mode

ION TRACK INSTRUMENTS

Leaders in Detection Technology

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Massachusetts 01887
USA
Tel: (978) 658-3767
Fax: (978) 657-5954

London Road
Pampisford
Cambridge, CB2 4EF
UK
Tel: (44) 01223 495510
Fax: (44) 01223 830133

The ITEMISER Contraband Detector is a dual function detection and identification system, ideally suited for detecting trace quantities of narcotics and explosives. The unique patented Ion Trap Mobility Spectrometer (ITMS®) in the ITEMISER Contraband Detector is the most sensitive narcotics and explosives detector available. It is now possible to successfully screen and search for the trace quantities of contraband that inevitably contaminate the surfaces of baggage, vehicles, cargo pallets, and all types of containers in which contraband is hidden. Any surface where contraband has been present, including walls and floors, furniture, and even people, can be tested.

The ITEMISER Contraband Detector switches instantly from a narcotics detector to an explosives detector–ideal for circumstances where the search mission is for both substances. The interactive touchscreen display, analyzer, sample collection system, and printer, are combined into one single-component instrument that is lightweight and easily transportable. Non-technical staff can be quickly trained to operate the system efficiently. When contraband is detected, the alarm panel flashes, the substance is identified, and an audible alarm sounds.

A sample collection is accomplished either by wiping a surface with a paper filter (trap) or by use of a battery operated hand-vacuum that uses the same trap. Independent government tests have shown this method collects 25 times more sample particles than by wiping with a glove or by simply vacuuming. In either case, the trap containing the sample is simply dropped into the ITEMISER sample inlet–automatically triggering the analysis. The ITEMISER confirms the presence or absence of contraband within five seconds, allowing thousands of samples to be processed each day.

ITEMISER®

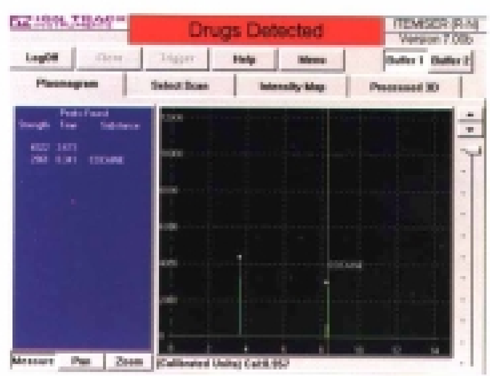
Narcotics and Explosives Detection and Identification System

Detects all common narcotics and explosives including: Heroin, Cocaine, THC, RDX, PETN, TNT, Dynamite and Semtex.

- Completely automatic analyzer.
- Switches detection modes (narcotics to explosives) in ten seconds.
- Continuous automatic internal calibration.
- Unique sample wipe technique is 25 times more efficient than other methods.
- Easily programmed for up to 40 substances of narcotics and explosives.
- Interactive touchscreen, analyzer, sample collection system, and printer are combined into one single-component instrument that is lightweight and easily transportable.
- Manufactured in an ISO 9002 certified production facility.
- Optional modem for remote trouble-shooting and data retrieval.

Uses:

- *Airports*
- *Courts and Detention Centers*
- *Customs*
- *Forensic Labs*
- *Correctional Facilities*
- *Law Enforcement.*



Plasmagram Alarm Screen - Narcotics

Data Display

The bar graph (Figure 1) changes color to indicate the strength of the alarm, or for a more detailed analysis, an ion signature spectrum known as a "plasmagram" (Figure 2) can also be easily selected. The ITEMISER can be set to automatically print out the plasmagram when the alarm signals or it can be stored on disk. The stored data includes the time, date and any notes entered at the time of the alarm. Complete history logs of sampled data can be stored, recalled and printed at any time.

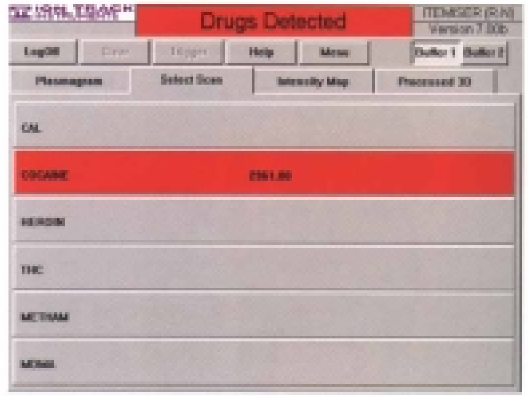


Figure 1. Bar Graph Alarm Screen - Narcotics

Specifications

Detector Type:	Ion Trap Mobility Spectrometer (ITMS®).	
Detector Sensitivity:	< 30 picograms for narcotics or explosives.	
Selectivity:	Less than 1% false positive rate.	
Analysis Time:	3-8 seconds per sample.	
Calibration:	Continuous automatic internal calibration. One-step manual verification.	
Sample Acquisition:	Surface wipe with paper sample trap by hand or with hand-vacuum. Air sampling possible with hand-vacuum.	
Warm-up Time:	The ITEMISER can be left on at all times *(warm-up from cold start is approximately 15 minutes).*	
Power Supply:	110/220 VAC 50/60 Hz user-selectable.	
Integral Computer:	Internal computer with hard disk, interactive touchscreen for input and display, printer, external floppy disk drive, and separate keyboard for entering comments and new substances.	
Signal Processing:	Output to bar graph or plasmagram display. Positive detection signals will alarm and can be stored for later analysis.	
Detected and Identified Substances:		
	Narcotics:	Cocaine, Heroin, THC, LSD, Morphine, Amphetamines, PCP and many others.
	Explosives:	PETN, TNT, Dynamite, C4, RDX, HMX, Semtex, Ammonium Nitrate, TNAB, TATP, HMTD and many others.

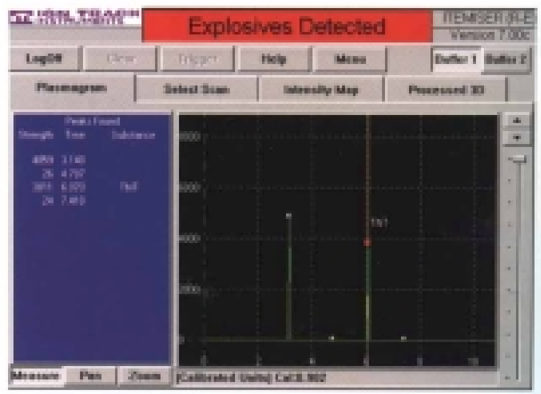


Figure 2. Plasmagram Alarm Screen - Explosives

WEIGHT	LENGTH	WIDTH	HEIGHT
43 lbs (19.5 kg)	18.5 in (47.0 cm)	21.0 in (53.5 cm)	14.5 in (37.0 cm)

ION TRACK INSTRUMENTS

Leaders in Detection Technology

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Tel: +44 (0) 1223 495510
Fax: +44 (0) 1223 830133
iontrack_uk@compuserve.com

VISIT OUR WEBSITE AT
www.iontrack.com

Appendix E: EXPRAY™ Material Safety Data Sheets

I. Material Safety Data Sheet

Product Name (Trade Name): Expray-1 Date Reviewed: 9/25/96
Catalog Number: 1510, 1515
Manufacturer: Erez Forensic Technology Ltd., Jerusalem, Israel
Importer: Mistral Security Inc.
Emergency Phone Numbers: (301) 913-9366 (Office Hours: 9:00-5:00 EST)

II. Hazardous Ingredient/Identity Information

Component	CAS#	Percent w/w	PEL (OSHA)	TLV (ACGIH)
			mg/M3	mg/M3
DMSO	67-68-5	45	No data	No data
TBAH	2052-49-5	3 - 3.5	No data	No data
Ethyl Alcohol	64-17-5	3 - 5	1900	1880
Methyl Alcohol	67-56-1	5	260	262
Propellant (LPG)	68476-85-7	40 - 45	1800	1800

III. Physical/Chemical Characteristics

Appearance and Odor: Yellowish liquid, characteristic odor.
Boiling Point: $< 0^{o}$ C, $> 100^{o}$ C (liquid phase)
Vapor Pressure: 3.2 bar @ 20^{o} C
Specific Gravity: ~ 1
Evaporation Rate (Butyl Acetate): > 1
Vapor Density: > 1
Solubility in Water: Soluble.
Melting point: $< -10^{o}$ C.
pH: 13.5
Decomposition Temperature: No data.

IV. Fire and Explosion Hazard Data

Flammability: Non-Flammable aerosol composition.
Flash Point: -74^{o} C (Propellant).
Upper Explosion Limits: 8.4% (Propellant).
Lower Explosion Limits: 1.8% (Propellant).
Extinguishing Media: Carbon Dioxide, Foam, Sand.
Fire Fighting Procedures: Use water spray to cool fire exposed aerosol containers when feasible, for containers can rupture violently from heat developed pressure.
Usual Fire Hazardous: May release CO, CO_2, SO_2, NO_2 at high temperatures.

V. Reactivity Data

Stable: Yes
Corrosive: Yes.
Hazardous Polymerization: Will not occur.
Incompatibility: Strong oxidizing material.
Hazardous Decomposition: will not occur under normal conditions.
Conditions to Avoid: High Temperature

VI. Health Hazard Data

Routs of Entry and First Aid Procedures:
Eyes: Flush Eyes with Plenty of water for at least 15 minutes, occasionally lifting the lower and upper lids.
Inhalation: For inhalation discomfort, remove to fresh air.
Skin: Wash skin with water and mild soap or waterless hand cleaner.
Ingestion: Entry by mouth, drink plenty of water and seek medical advise.
Health Hazards: Acute: Product concentration above the permissible exposure limit may cause temporary respiratory tract discomfort and irritaion of eyes and skin.
Chronic: No data.
Symptoms of Exposure: Coughing or sneezing, runny watery eyes.
Medical Conditions: Aggravated: No Data.

VII. Precaution for Safe Handling and Use

If material is spilled: Spills from aerosol cans are unlikely and are generally of small volume. Spill prevention is therefore not normally considered a problem. In case of actual spill or rupture, avoid breathing vapors and ventilate area well. Remove all sources of ignition and use non sparking equipment. Soak up material with inert absorbents and place in safety containers for proper disposal.
Waste Disposal Method: Dispose in accordance with local, state and federal regulations.
Precautions for Handling/Storing: Use and store with adequate ventilation in a cool place.
Other precautions: Do not expose to temperatures exceeding 50 C.

DO NOT INCINERATE AEROSOL CANS

VIII. Control Measures

Respiratory Protection: NIOSH approved respiratory protection required when vapor concentration exceed TLV/PEL.
Ventilation: Sufficient to maintain below TLV.
Protective Gloves: Not required under normal use.
Eye Protection: Not required under normal use.
Other Protective Equipment: Not required.
Work and Hygienic Practices: Employ good industrial hygiene practices by using adequate ventilation and personal protection.

The suggestions and data provided herewith are based upon tests and information which we believe to be reliable. The information is believes to be accurate and represents the best information currently available to us. However, we make no guarantee with respects thereto and assume no liability resulting from the use thereof. Users should make their own investigations to determine the suitability of the information or products for their particular purpose. Furthermore, nothing contained herein is intended as permission, inducement or recommendation to violate any laws or to practice any invention covered by existing patents.

This form meets or exceeds the requirements of OSHA form #174.

I. Material Safety Data Sheet

Product Name (Trade Name): Expray-2 Date Reviewed: 9/25/96
Catalog Number: 1520, 1525
Manufacturer: Erez Forensic Technology Ltd., Jerusalem, Israel
Importer: Mistral Security Inc.
Emergency Phone Numbers: (301) 913-9366 (Office Hours: 9:00-5:00 EST)

II. Hazardous Ingredient/Identity Information

Component	CAS#	Percent w/w	PEL (OSHA)	TLV (ACGIH)
			mg/M3	mg/M3
Sulphanilamide	63-74-1	2	No data	No data
Phosphoric acid	7664-38-2	5	1	1
Water	7732-18-5	55 - 60	No data	No data
Propellant (LPG)	68476-85-7	30 - 35	1800	1800

III. Physical/Chemical Characteristics

Appearance and Odor: Colorless liquid, No noticeable odor.
Boiling Point: $< 0^{o}$ C, $> 100^{o}$ C (liquid phase)
Vapor Pressure: 3.2 bar @ 20^{o} C
Specific Gravity: ~ 1
Evaporation Rate (Butyl Acetate): > 1
Vapor Density: > 1
Solubility in Water: Soluble.
Melting point: $< -10^{o}$ C.
pH: 0.5
Decomposition Temperature: No data.

IV. Fire and Explosion Hazard Data

Flammability: Non-Flammable aerosol composition.
Flash Point: -74^{o} C (Propellant).
Upper Explosion Limits: 8.4% (Propellant).
Lower Explosion Limits: 1.8% (Propellant).
Extinguishing Media: Carbon Dioxide, Foam, Sand.
Fire Fighting Procedures: Use water spray to cool fire exposed aerosol containers when feasible, for containers can rupture violently from heat developed pressure.
Usual Fire Hazardous: May release CO, CO_2, SO_2, NO_2 at high temperatures.

V. Reactivity Data

Stable: Yes
Corrosive: Yes.
Hazardous Polymerization: Will not occur.
Incompatibility: Metal Powder.
Hazardous Decomposition: will not occur under normal conditions.
Conditions to Avoid: High Temperature

VI. Health Hazard Data

Routs of Entry and First Aid Procedures:
Eyes: Flush Eyes with Plenty of water for at least 15 minutes, occasionally lifting the lower and upper lids.
Inhalation: For inhalation discomfort, remove to fresh air.
Skin: Wash skin with water and mild soap or waterless hand cleaner.
Ingestion: Entry by mouth, drink plenty of water and seek medical advise.
Health Hazards: Acute: Product concentration above the permissible exposure limit may cause temporary respiratory tract discomfort and irritaion of eyes and skin.
Chronic: No data.
Symptoms of Exposure: Coughing or sneezing, runny watery eyes.
Medical Conditions: Aggravated: No Data.

VII. Precaution for Safe Handling and Use

If material is spilled: Spills from aerosol cans are unlikely and are generally of small volume. Spill prevention is therefore not normally considered a problem. In case of actual spill or rupture, avoid breathing vapors and ventilate area well. Remove all sources of ignition and use non sparking equipment. Soak up material with inert absorbents and place in safety containers for proper disposal.
Waste Disposal Method: Dispose in accordance with local, state and federal regulations.
Precautions for Handling/Storing: Use and store with adequate ventilation in a cool place.
Other precautions: Do not expose to temperatures exceeding 50 C.

DO NOT INCINERATE AEROSOL CANS

VIII. Control Measures

Respiratory Protection: NIOSH approved respiratory protection required when vapor concentration exceed TLV/PEL.
Ventilation: Sufficient to maintain below TLV.
Protective Gloves: Not required under normal use.
Eye Protection: Not required under normal use.
Other Protective Equipment: Not required.
Work and Hygienic Practices: Employ good industrial hygiene practices by using adequate ventilation and personal protection.

The suggestions and data provided herewith are based upon tests and information which we believe to be reliable. The information is believes to be accurate and represents the best information currently available to us. However, we make no guarantee with respects thereto and assume no liability resulting from the use thereof. Users should make their own investigations to determine the suitability of the information or products for their particular purpose. Furthermore, nothing contained herein is intended as permission, inducement or recommendation to violate any laws or to practice any invention covered by existing patents.

This form meets or exceeds the requirements of OSHA form #174.

I. Material Safety Data Sheet

Product Name (Trade Name): Expray-3 Date Reviewed: 9/25/96
Catalog Number: 1530, 1535
Manufacturer: Erez Forensic Technology Ltd., Jerusalem, Israel
Importer: Mistral Security Inc.
Emergency Phone Numbers: (301) 913-9366 (Office Hours: 9:00-5:00 EST)

II. Hazardous Ingredient/Identity Information

Component	CAS#	Percent w/w	PEL (OSHA)	TLV (ACGIH)
			mg/M3	mg/M3
Zinc Dust	7440-66-6	1 - 2	No data	No data
IPA	69-63-0	15 - 20	980	983
Propellant (LPG)	68476-85-7	80	1910	1910

III. Physical/Chemical Characteristics

Appearance and Odor: Colorless liquid, No noticeable odor.
Boiling Point: $< 0^{o}$ C, $\sim 75^{o}$ C (liquid phase)
Vapor Pressure: 3 bar @ 20^{o} C
Specific Gravity: ~ 0.8
Evaporation Rate (Butyl Acetate): > 2
Vapor Density: > 1.5
Solubility in Water: Soluble.
Melting point: $< -40^{o}$ C.
pH: Not applicable.
Decomposition Temperature: No data.

IV. Fire and Explosion Hazard Data

Flammability: Flammable aerosol composition.
Flash Point: -74^{o} C (Propellant).
Upper Explosion Limits: 8.4% (Propellant).
Lower Explosion Limits: 1.8% (Propellant).
Extinguishing Media: Carbon Dioxide, Foam, Sand.
Fire Fighting Procedures: Use water spray to cool fire exposed aerosol containers when feasible, for containers can rupture violently from heat developed pressure.
Usual Fire Hazardous: May release CO, CO_2 at high temperatures.

V. Reactivity Data

Stable: Yes
Corrosive: No.
Hazardous Polymerization: Will not occur.
Incompatibility: Strong acids, strong oxidizing material.
Hazardous Decomposition: will not occur under normal conditions.
Conditions to Avoid: High Temperature

VI. Health Hazard Data

Routs of Entry and First Aid Procedures:
Eyes: Flush Eyes with Plenty of water for at least 15 minutes, occasionally lifting the lower and upper lids.
Inhalation: For inhalation discomfort, remove to fresh air.
Skin: Wash skin with water and mild soap or waterless hand cleaner.
Ingestion: Entry by mouth, drink plenty of water and seek medical advise.
Health Hazards: Acute: Product concentration above the permissible exposure limit may cause temporary respiratory tract discomfort and irritaion of eyes and skin.
Chronic: No data.
Symptoms of Exposure: Coughing or sneezing, runny watery eyes.
Medical Conditions: Aggravated: No Data.

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Eye Protection: Not required under normal use.
Other Protective Equipment: Not required.
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The suggestions and data provided herewith are based upon tests and information which we believe to be reliable. The information is believes to be accurate and represents the best information currently available to us. However, we make no guarantee with respects thereto and assume no liability resulting from the use thereof. Users should make their own investigations to determine the suitability of the information or products for their particular purpose. Furthermore, nothing contained herein is intended as permission, inducement or recommendation to violate any laws or to practice any invention covered by existing patents.

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14. ABSTRACT

The U.S. Army has numerous excess ordnance production facilities slated for destruction. These buildings may have considerable quantities of residual energetic materials (EMs) and asbestos, and may also be structurally unsound. The EMs in these facilities include finished military explosives, propellants, and pyrotechnics as well as precursors to these materials. The Construction Engineering Research Laboratory (CERL) is developing alternatives for safe, economic, and environmentally benign assessment, decontamination, and disposal of excess ordnance production facilities.

For this study, CERL selected four EM detection technologies and tested them at the Radford Army Ammunition Plant (RAAP) in Virginia. Facilities selected as test sites reflected as much variation in EM usage, construction, building materials, and other conditions as possible.

All of the instruments evaluated in this study are capable of detecting EMs. They are designed and were demonstrated to be very sensitive to small levels of contamination. Instrument performance was not hindered by either the conditions at RAAP or the building material substrate. Each instrument had superior qualities, as well as features less suited for use in field work like that experienced at RAAP.

15. SUBJECT TERMS

energetic material (EM)	Army Ammunition Plant (AAP)	munitions waste disposal	facilities management
detection devices	explosives	demolition	

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